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PATENT APPLICATION/PCT
Attorney Docket No. 1217-020120

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of	:	
Reo YAMAMOTO Yoshihide KAMIYAMA	: :	PROCESS FOR PRODUCING SINTERED ALUMINUM NITRIDE FURNISHED WITH VIA HOLE
International Application No. PCT/JP01/04617	: :	
International Filing Date 31 May 2001	: :	
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Pittsburgh, Pennsylvania
February 6, 2002

PRELIMINARY AMENDMENT

Box PCT
Commissioner for Patents
Washington, D.C. 20231

Sir:

Prior to initial examination, please amend the above-identified patent application as follows:

IN THE SPECIFICATION:

On page 1, please delete the section heading "DESCRIPTION".

Please replace the section heading beginning at page 1, line 6 with the following rewritten section heading:

BACKGROUND OF THE INVENTION

On page 1, please delete the section heading "BACKGROUND ART".

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Please replace the section heading beginning at page 3, line 19 with the following rewritten section heading:

SUMMARY OF THE INVENTION

Please replace the partial paragraph beginning at page 4, line 3 with the following rewritten partial paragraph:

In particular, according to one aspect of the present invention, a process is provided for producing a sintered aluminum nitride furnished with via holes, comprising providing an aluminum nitride molding having through-holes for via hole formation and through-holes for formation of dummy via holes not used for electrical connect, filling the through-holes for via hole formation and the through-holes for dummy via hole formation with a conductive paste and firing the aluminum nitride molding and conductive paste,

Please replace the section heading beginning at page 5, line 6 with the following rewritten section heading:

BRIEF DESCRIPTION OF THE DRAWINGS

Please replace the paragraph beginning at page 5, line 7 with the following rewritten paragraph:

Fig. 1 is a plan of an aluminum nitride molding furnished with through-holes for via hole formation and through-holes for dummy via hole formation according to the present invention, wherein the circle shows a boundary defined by a radius of 5.0 mm from the center of a through-hole for via hole formation; and

On page 5, please delete the partial paragraph beginning at line 16.

On page 5, please delete the partial paragraph beginning at line 17.

On page 5, please delete the partial paragraph beginning at line 18.

On page 5, please delete the partial paragraph beginning at line 19.

Please replace the section heading beginning at page 5, line 21 with the following rewritten section heading:

DETAILED DESCRIPTION OF THE INVENTION

Please replace the paragraph beginning at page 5, line 22 with the following rewritten paragraph:

In the present invention, the aluminum nitride molding 1 is obtained by molding a composition comprising powdery aluminum nitride, a sintering aid and organic ingredients such as an organic binder. Although the configuration thereof is not particularly limited, it is generally preferred that the aluminum nitride molding 1 be in the form of a sheet having scrap zones 4 around its outer periphery and positioned within the region between chips to be cut.

Please replace the paragraph beginning at page 6, line 4 with the following rewritten paragraph:

The aluminum nitride molding is furnished with at least one through-hole 2 for via hole formation. At least one of the through-holes 2 for via hole formation is provided in such a highly isolated state that, therearound, other through-holes for via hole formation are not densely present. As aforementioned, when an aluminum nitride molding 1 having highly isolated through-holes 2 for via hole formation is fired, the influence of a shrinkage factor difference between conductive portions and sintered portions of aluminum nitride is so high that a sintering balance would be deteriorated with the result that poor densification of via holes, or poor appearance such as cracking attributed thereto would be likely to occur. Therefore, the effect of the present invention can be favorably attained by using the above aluminum nitride molding as an object to be wrought.

Please replace the paragraph beginning at page 6, line 19 with the following rewritten paragraph:

In the present invention, the above problems of the prior art are solved by furnishing the aluminum nitride molding 1 with the through-holes 2 for via hole formation and the through-holes 3 for formation of dummy via holes not used for electrical connection so that the through-holes 2 for via hole formation having been filled with the conductive paste and the aluminum nitride molding respectively exhibit a firing shrinkage factor (Xv, %) and a firing shrinkage factor (Xs, %) whose difference, Xv - Xs, is in the range of -1.0 to 9.5%, preferably 1.0 to 5.5%, and still preferably 1.7 to 4.5%.

Please replace the paragraph beginning at page 7, line 5 with the following rewritten paragraph:

The conductive paste which is filled in the through-holes 2 contains the refractory metal as described later. When the refractory metal is buried in the aluminum nitride molding, while the firing shrinkage factor (Xs) of aluminum nitride molding is substantially not varied by an increase or a decrease of the content of refractory metal, the firing shrinkage factor (Xv) of through-holes 2 for via hole formation becomes approximately equal to or greater than the value of Xs in accordance with the increase of the content of buried refractory metal. On the other hand, when the content of buried refractory metal is decreased, the value of Xv becomes smaller than the value of Xs. Xs and Xv are not necessarily to be equal, and there would be no problem as long as they are balanced so as to fall within certain limits. However, when the difference of firing shrinkage factor, Xv - Xs, is less than -1.0%, there would occur poor densification of via holes, or, attributed thereto, cracking of internal conductive layers and poor appearance. On the other hand, when the difference of firing shrinkage factor exceeds 9.5%, there would occur cracking of sintered portions of aluminum nitride.

Please replace the paragraph beginning at page 8, line 1 with the following rewritten paragraph:

Therefore, in the present invention, in order to eliminate the influence of the shrinkage factor difference between conductive portions and sintered portions of aluminum nitride, the aluminum nitride molding is furnished with not only the through-holes 2 for via hole formation but also the through-holes 3 of formation of dummy via holes not used for electrical connected to thereby appropriately regulate the values of (Xv) and (Xs).

Please replace the partial paragraph beginning at page 8, line 13 with the following rewritten partial paragraph:

wherein Ra represents the diameter of via hole measured after being polished to a mirror-like surface of sintered aluminum nitride, and Rb represents the diameter of a punching metal mold employed for forming the through-hole for via hole formation.

Please replace the partial paragraph beginning at page 8, line 21 with the following rewritten partial paragraph:

wherein La represents the center distance of the remotest two via holes opposite to each other, with at least part of the via hole for Xv determination interposed therebetween. The two via holes are selected from the dummy via holes and other via holes which are present around the via hole formed from the via hole formation through-hole for determination of firing shrinkage factor (Xv), i.e., within a radius of 5.0 mm from the center of via hole formation through-hole as described below. The La is measured after polishing to form a mirror-like finish on the sintered aluminum nitride. The Lb measurement is made in the same manner as the La measurement but is made on the unfired aluminum nitride molding prior to sintering. When only one dummy via hole is formed or when any two selected from among dummy via holes and other via holes are not in such a positional relationship that they are opposite to each other with the via hole for (Xv) determination

interposed therebetween, the distance corresponding to the above center distance can be determined by effecting marking by, for example, dimple or through-hole formation at a position close to the periphery around the above via hole on an extension line passing through the center of the remotest via hole among these other via holes and dummy via holes and the center of via hole for (Xv) determination.

Please replace the paragraph beginning at page 11, line 15 with the following rewritten paragraph:

The most remarkable characteristic of the present invention resides in that, in the production of a substrate of sintered aluminum nitride from the aluminum nitride molding having highly isolated through-holes 2 for via hole formation, at least one through-hole for formation of dummy via holes 3 not used for electrical connected on the substrate after firing is formed around each of the highly isolated through-holes 2 for via hole formation.

Please replace the paragraph beginning at page 11, line 23 with the following rewritten paragraph:

By virtue of the formation of through-holes for dummy via hole formation, the highly isolated through-hole for via hole formation can be converted to the through-hole around which through-holes for dummy via hole formation and other through-holes for via hole formation are densely present. As a result, with respect to the sintered aluminum nitride obtained by filling these through-holes with the conductive paste and performing a firing, the poor densification of via holes and the problem of poor appearance are greatly resolved.

Please replace the paragraph beginning at page 13, line 17 with the following rewritten paragraph:

The sintered aluminum nitride produced by the present invention, when used as a substrate for semiconductor mounting, is generally cut into a plurality of small chips in rectangular or other form. At that time, the periphery of sintered aluminum nitride and

partition zones between neighboring small chips are cut off or otherwise machined for scrapping. Therefore, in the present invention, it is preferred that the through-holes for dummy via hole formation be disposed in the scrap zones 4 (zones to be scrapped) of sintered aluminum nitride, positioned within the region around the highly isolated through-hole for via hole formation.

Please replace the paragraph beginning at page 14, line 4 with the following rewritten paragraph:

When the sintered aluminum nitride is in the form of a sheet, the scrap zones 4 are generally provided as a sheet periphery and a partition zone between small chips cut out, each having a width of 0.3 to 2 mm.

Please replace the paragraph beginning at page 14, line 8 with the following rewritten paragraph:

The method of furnishing the aluminum nitride molding with through-holes for dummy via hole formation will now be described in detail with reference to Fig. 2 showing the aluminum nitride molding furnished with through-holes 2 for via hole formation according to the prior art and Fig. 1 showing the aluminum nitride molding of Fig. 2 further furnished with through-holes 3 for dummy via hole formation according to the present invention. Referring to Fig. 2, the aluminum nitride molding 1 is fired into the sintered aluminum nitride, from which a multiplicity of rectangular small chips are cut out as shown by partition lines. In the aluminum nitride molding 1, through-hole 2 for formation of a via hole used for electrical connection of both major surfaces of a substrate is disposed in the center of each small chip partitioned. Each through-hole 2 for via hole formation is in such a highly isolated state that, within a radius of 5.0 mm from the through-hole center (within dotted line circle), other through-holes for via hole formation are only present in the aforementioned amount. When the conventional aluminum nitride molding 1 of Fig. 2 is

fired, the sintered aluminum nitride would be likely to suffer from, as aforementioned, poor densification of via holes and hence problems of cracking and a drop of the positional accuracy of via holes would result.

Please replace the partial paragraph beginning at page 15, line 21 with the following rewritten partial paragraph:

In the present invention, the aluminum nitride powder for constituting the aluminum nitride molding is not particularly limited, and a known powder can be used. In particular, aluminum nitride powder of 5 μm or less average particle diameter is preferred, aluminum nitride powder of 0.3 μm or less average particle diameter is still more preferred, and aluminum nitride powder of 0.5 to 2 μm average particle diameter is especially preferred, the average particle diameter measured by the sedimentation method. Moreover, the aluminum nitride powder having an average particle diameter D1 as calculated from the specific surface area thereof and an average particle diameter D2 as measured by the sedimentation method which satisfy the following formulas,

Please replace the paragraph beginning at page 16, line 20 with the following rewritten paragraph:

In the aluminum nitride powder, the oxygen content is 3.0% by weight or less, and, when the aluminum nitride composition is AlN, the content of cationic impurities is 0.5% by weight or less. It is especially preferred to employ an aluminum nitride powder wherein the oxygen content is in the range of 0.4 to 1.0% by weight, the content of cationic impurities 0.2% by weight or less, and the total content of Fe, Ca, Si and C among cationic impurities 0.17% by weight or less. When this aluminum nitride powder is employed, the resulting sintered aluminum nitride exhibits a greatly increased thermal conductivity.

Please replace the paragraph beginning at page 19, line 1 with the following rewritten paragraph:

The thus formed through-holes for via hole formation and through-holes for dummy via hole formation are filled with a conductive paste obtained by mixing a refractory metal powder and an organic vehicle into a paste.

Please replace the paragraph beginning at page 20, line 11 with the following rewritten paragraph:

It is generally preferred that the organic vehicle component be added in an amount of 2 to 9 parts by weight per 100 parts by weight of the refractory metal powder. When the amount of organic vehicle is less than 2 parts by weight, the inorganic substance powder cannot be satisfactorily dispersed and forming the same into a paste is difficult, so that the filling property would be deteriorated. On the other hand, when the amount of organic vehicle is greater than 9 parts by weight, the inorganic substance concentration of the conductive paste becomes relatively low causing the unfavorable occurrence of poor densification of the via holes.

Please replace the paragraph beginning at page 20, line 23 with the following rewritten paragraph:

In the present invention, the conductive paste preferably contains an aluminum nitride powder. The aluminum nitride powder is effective in enhancing the sinterability of the refractory metal and enhancing the adherence thereof to the sintered aluminum nitride molding 1. Further, by virtue of the presence of the aluminum nitride powder in the conductive paste, the difference in the shrinkage factor between the aluminum nitride portion and conductive portion is reduced to thereby enhance the dimensional stability of sintered product in order that the object of the present invention can be more favorably attained.

Please replace the paragraph beginning at page 21, line 9 with the following rewritten paragraph:

With respect to the aluminum nitride powder, a known powder can be used without any particular limitation. In particular, the aforementioned aluminum nitride powder preferably used in the aluminum nitride molding is excellent in the sinterability with the refractory metal and is effective in enhancing the adherence of the conductive portion. The aluminum nitride powder is generally added in an amount of 2 to 10 parts by weight, preferably 3 to 7 parts by weight, per 100 parts by weight of the refractory metal powder.

Please replace the paragraph beginning at page 21, line 18 with the following rewritten paragraph:

In the conductive paste composition, when the amount of aluminum nitride is less than 2 parts by weight, the adhesion strength between the conductive portion and the sintered aluminum nitride tends to decrease, or the shrinkage factor difference between the sintered aluminum nitride portion and the conductive portion tends to increase, so that the danger of void occurrence at a junction interface would be high. On the other hand, when the amount of aluminum nitride is greater than 10 parts by weight, the viscosity of the conductive paste tends to increase so as to suffer deterioration of the filling property. As a result, the adhesion strength between the conductive portion and the sintered aluminum nitride tends to be decreased by voids occurring in the conductive portion, or the surface of the conductive portion tends to be discolored by the aluminum nitride, to thereby invite the danger of an increase of electrical resistance of the via holes. Moreover, in the event that voids have occurred at the junction interface or in the conductive portion as mentioned above, a gas or liquid would be trapped in the voids in the process of thin film formation with the result that a film detachment by expansion of gas or liquid, or a drop of film adhesion strength by dirt sticking to the surface of sintered product would tend to occur.

Please replace the paragraph beginning at page 23, line 11 with the following rewritten paragraph:

With respect to the method of dewaxing, generally performed methods can be employed without limitation. The dewaxing atmosphere is not particularly limited as long as an oxidative atmosphere such as atmospheric air which might oxidize the refractory metal is avoided. For example, there can preferably be employed an atmosphere of an inert gas such as nitrogen, argon or helium; an atmosphere of a reducing gas such as hydrogen; an atmosphere of a gas consisting of a mixture thereof; an atmosphere of a gas thereof which has been humidified; or a vacuum.

Please replace the paragraph beginning at page 25, line 20 with the following rewritten paragraph:

In order to obtain sintered aluminum nitride of high thermal conductivity, it is desirable to fire the aluminum nitride molding after it has been dewaxed so that the residual carbon ratio of the aluminum nitride molding falls within the range of 800 to 3000 ppm (hereinafter referred to simply as "dewaxed material") at 1200 to 1700°C, preferably 1500 to 1650°C, and thereafter 1800 to 1950°C, preferably 1820 to 1900°C. When dewaxing is performed so as to ensure a high residual carbon ratio, the resultant sintered aluminum nitride is generally likely to suffer from the problems of poor densification of via holes and poor appearance such as cracking, while the above high thermal conductivity can be ensured. These problems can be resolved by the above two step firing.

Please replace the paragraph beginning at page 26, line 23 with the following rewritten paragraph:

It is preferred that the first-step firing temperature range from 1500 to 1650°C from the viewpoint that the oxygen removing reaction by reduction can be promoted with especially high efficiency so as to increase the thermal conductivity of the sintered aluminum

nitride. When the second-step firing temperature is lower than 1800°C, it would not be feasible to satisfactorily sinter the aluminum nitride. As the result, it would not be feasible to satisfactorily increase the thermal conductivity of the sintered aluminum nitride.

On page 30, please delete the section heading "EFFECT OF THE INVENTION".

Please replace the partial paragraph beginning at page 32, line 11 with the following rewritten partial paragraph:

On a sintered aluminum nitride after being polished like a mirror surface, five via holes were randomly selected, and the diameters thereof were measured and averaged to thereby obtain an average diameter Ra. The firing shrinkage factor was calculated by the formula:

Please replace the partial paragraph beginning at page 32, line 17 with the following rewritten partial paragraph:

wherein Ra represents an average of the diameters of five via holes measured on a sintered aluminum nitride after being polished to a mirror-like surface, and Rb represents the diameter of a punching metal mold employed for forming the through-holes for via hole formation.

Please replace the paragraph beginning at page 32, line 24 with the following rewritten paragraph:

With respect to each of the through-holes of aluminum nitride molding for formation of five via holes selected in the above measurement of firing shrinkage factor (Xv), the center distance of two via holes of remotest positional relationship opposite to each other, with at least part of the above through-hole for via hole formation interposed therebetween was measured by the use of a measure scope. The two via holes are selected from the other through-holes via hole formation and through-holes for dummy via hole formation which

were present within a radius of 5.0 mm from the center of the through hole for via hole formation used for measurement of (Xv). The measured center distances were averaged, and designated Lb. Moreover, with respect to the sintered product from the aluminum nitride molding, after being polished like a mirror surface, the center distances between two via holes derived from the other through-holes for via hole formation and through-holes for dummy via hole formation used for measuring the above average Lb were measured. The measured center distances were averaged, and designated La.

Please replace the partial paragraph beginning at page 34, line 5 with the following rewritten partial paragraph:

Sintered aluminum nitride was subjected to polishing to produce a mirror-like surface. In a high vacuum of 10^{-3} torr, 0.06 μm thick Ti, 0.2 μm thick Pt and 0.6 μm thick Au metallic thin films were sequentially formed on the surface by sputtering. The resultant sintered aluminum nitride was allowed to stand still in the atmospheric air at 450°C for 5 min, and the appearance thereof was observed by visual inspection and through a stereomicroscope (μ40). The appearance was evaluated on the following criteria:

Please replace the paragraph beginning at page 35, line 10 with the following rewritten paragraph:

Sintered aluminum nitride, after polishing to mirror-like surface, was cut and divided into small chips. Thereafter, the electrical resistance of via holes was measured.

<u>IN THE CLAIMS</u>:

Please amend claim 5 as follows:

5. The process as claimed in claim 1, wherein through-holes for dummy via hole formation are formed in a scrap zone within the sintered aluminum nitride.

Please amend claim 7 as follows:

7. The process as claimed in claim 1, wherein a composition comprising 100 parts by weight of a refractory metal, 2 to 10 parts by weight of powdery aluminum nitride and 2 to 9 parts by weight of an organic vehicle is used as the conductive paste.

Please add new claims 9-14 as follows:

9. The process as claimed in claim 2, wherein through-holes for dummy via hole formation are formed in a scrap zone within the sintered aluminum nitride.

10. The process as claimed in claim 3, wherein through-holes for dummy via hole formation are formed in a scrap zone within the sintered aluminum nitride.

11. The process as claimed in claim 4, wherein through-holes for dummy via hole formation are formed in a scrap zone within the sintered aluminum nitride.

12. The process as claimed in claim 9, wherein, after the firing, the scrap zone is cut off from the sintered aluminum nitride.

13. The process as claimed in claim 2, wherein a composition comprising 100 parts by weight of a refractory metal, 2 to 10 parts by weight of powdery aluminum nitride and 2 to 9 parts by weight of an organic vehicle is used as the conductive paste.

14. The process as claimed in claim 13, wherein the aluminum nitride molding, after the filling of the through-holes for via hole formation and through-holes for dummy via hole formation with the conductive paste, is dewaxed so that the aluminum nitride molding exhibits an internal residual carbon ratio of 800 to 3000 ppm, then fired at 1200 to 1700°C and further fired at 1800 to 1950°C.

<u>IN THE ABSTRACT</u>:

Please replace the section heading beginning at page 51, line 1 with the following section heading:

ABSTRACT OF THE DISCLOSURE

REMARKS

The specification and claims have been amended to place the application in conformance with standard United States patent practice.

Attached hereto is a marked-up version of the changes made to the specification by the current amendment. The attachment is captioned "VERSION WITH MARKINGS TO SHOW CHANGES MADE".

Examination and allowance of pending claims 1-14 are respectfully requested.

Respectfully submitted,

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

In the specification:

Section heading beginning at page 1, line 6 has been amended as follows:

[TECHNICAL FIELD] BACKGROUND OF THE INVENTION

Section heading beginning at page 3, line 19 has been amended as follows:

[DISCLOSURE] SUMMARY OF THE INVENTION

Partial paragraph beginning at page 4, line 3 has been amended as follows:

In particular, according to one aspect of the present invention, ~~there is provided~~ a process is provided for producing a sintered aluminum nitride furnished with via holes, comprising providing an aluminum nitride molding having through-holes for via hole formation and through-holes for formation of dummy via holes not used for electrical connect, filling the through-holes for via hole formation and the through-holes for dummy via hole formation with a conductive paste and firing the aluminum nitride molding and conductive paste,

Section heading beginning at page 5, line 6 has been amended as follows:

BRIEF DESCRIPTION OF THE [DRAWING] DRAWINGS

Paragraph beginning at page 5, line 7 has been amended as follows:

Fig. 1 is a plan of an aluminum nitride molding furnished with through-holes for via hole formation and through-holes for dummy via hole formation according to the present invention~~. The dotted line~~, wherein the circle shows a boundary defined by a radius of 5.0 mm from the center of a through-hole for via hole formation~~.~~; and

Section heading beginning at page 5, line 21 has been amended as follows:

[BEST MODE FOR CARRYING OUT] DETAILED DESCRIPTION OF THE INVENTION

Paragraph beginning at page 5, line 22 has been amended as follows:

In the present invention, the aluminum nitride molding 1 is obtained by molding a composition comprising powdery aluminum nitride, a sintering aid and organic ingredients such as an organic binder. Although the configuration thereof is not particularly limited, it is generally preferred that the aluminum nitride molding 1 be in the form of a sheet having scrap zones 4 around its outer periphery and positioned within the region between chips to be cut.

Paragraph beginning at page 6, line 4 has been amended as follows:

The aluminum nitride molding is furnished with at least one through-hole 2 for via hole formation. At least one of the through-holes 2 for via hole formation is provided in such a highly isolated state that, therearound, other through-holes for via hole formation are not densely present. As aforementioned, when an aluminum nitride molding 1 having highly isolated through-holes 2 for via hole formation is fired, the influence of a shrinkage factor difference between conductive portions and sintered portions of aluminum nitride is so high that a sintering balance would be deteriorated with the result that poor densification of via holes, or poor appearance such as cracking attributed thereto would be likely to occur. Therefore, the effect of the present invention can be favorably attained by using the above aluminum nitride molding as an object to be wrought.

Paragraph beginning at page 6, line 19 has been amended as follows:

In the present invention, the above problems of the prior art are solved by furnishing the aluminum nitride molding 1 with the through-holes 2 for via hole formation and the through-holes 3 for formation of dummy via holes not used for electrical connection so that the through-holes 2 for via hole formation having been filled with the conductive paste and the aluminum nitride molding respectively exhibit

a firing shrinkage factor (Xv, %) and a firing shrinkage factor (Xs, %) whose difference, Xv - Xs, is in the range of -1.0 to 9.5%, preferably 1.0 to 5.5%, and still preferably 1.7 to 4.5%.

Paragraph beginning at page 7, line 5 has been amended as follows:

The conductive paste which is filled in the through-holes 2 contains the refractory metal as described later. When the refractory metal is buried in the aluminum nitride molding, while the firing shrinkage factor (Xs) of aluminum nitride molding is substantially not varied by an increase or a decrease of the content of refractory metal, the firing shrinkage factor (Xv) of through-holes 2 for via hole formation becomes approximately equal to or greater than the value of Xs in accordance with the increase of the content of buried refractory metal. On the other hand, when the content of buried refractory metal is decreased, the value of Xv becomes smaller than the value of Xs. Xs and Xv are not necessarily to be equal, and there would be no problem as long as they are balanced so as to fall within certain limits. However, when the difference of firing shrinkage factor, Xv - Xs, is less than -1.0%, there would occur poor densification of via holes, or, attributed thereto, cracking of internal conductive layers and poor appearance. On the other hand, when the difference of firing shrinkage factor exceeds 9.5%, there would occur cracking of sintered portions of aluminum nitride.

Paragraph beginning at page 8, line 1 has been amended as follows:

Therefore, in the present invention, in order to eliminate the influence of the shrinkage factor difference between conductive portions and sintered portions of aluminum nitride, the aluminum nitride molding is furnished with not only the through-holes 2 for via hole formation but also the through-holes 3 of formation of

dummy via holes not used for electrical connected to thereby appropriately regulate the values of (Xv) and (Xs).

Partial paragraph beginning at page 8, line 13 has been amended as follows:

wherein Ra represents the diameter of via hole measured after ~~polish like a~~ being polished to a mirror-like surface of sintered aluminum nitride, and Rb represents the diameter of a punching metal mold employed for forming the through-hole for via hole formation.

Partial paragraph beginning at page 8, line 21 has been amended as follows:

wherein La represents the center distance of the remotest two via holes opposite to each other, with at least part of the via hole for Xv determination interposed therebetween. The two via holes are selected from the dummy via holes and other via holes which are present around the via hole formed from the via hole formation through-hole for determination of firing shrinkage factor (Xv), i.e., within a radius of 5.0 mm from the center of via hole formation through-hole as described below. The La is measured after ~~polish like~~ polishing to form a ~~mirror surface of~~ mirror-like finish on the sintered aluminum nitride. The Lb measurement is made in the same manner as the La measurement but is made on the unfired aluminum nitride molding prior to sintering. When only one dummy via hole is formed or when any two selected from among dummy via holes and other via holes are not in such a positional relationship that they are opposite to each other with the via hole for (Xv) determination interposed therebetween, the distance corresponding to the above center distance can be determined by effecting marking by, for example, dimple or through-hole formation at a position close to the periphery around the above via hole on an extension line passing through the center of the remotest via hole among these other via holes and dummy via holes and the center of via hole for (Xv) determination.

Paragraph beginning at page 11, line 15 has been amended as follows:

The most remarkable characteristic of the present invention resides in that, in the production of a substrate of sintered aluminum nitride from the aluminum nitride molding having highly isolated through-holes 2 for via hole formation, at least one through-hole for formation of dummy via holes 3 not used for electrical connected on the substrate after firing is formed around each of the highly isolated through-holes 2 for via hole formation.

Paragraph beginning at page 11, line 23 has been amended as follows:

By virtue of the formation of through-holes for dummy via hole formation, the highly isolated through-hole for via hole formation can be converted to the through-hole around which through-holes for dummy via hole formation and other through-holes for via hole formation are densely present. As a result, with respect to the sintered aluminum nitride obtained by filling these through-holes with the conductive paste and performing a firing, the poor densification of via holes and the problem of poor appearance are greatly resolved ~~greatly~~.

Paragraph beginning at page 13, line 17 has been amended as follows:

The sintered aluminum nitride produced by the present invention, when used as a substrate for semiconductor mounting, is generally cut into a plurality of small chips in rectangular or other form. At that time, the periphery of sintered aluminum nitride and partition zones between neighboring small chips are cut off or otherwise machined for scrapping. Therefore, in the present invention, it is preferred that the through-holes for dummy via hole formation be disposed in the scrap zones 4 (zones to be scrapped) of sintered aluminum nitride, positioned within the region around the highly isolated through-hole for via hole formation.

Paragraph beginning at page 14, line 4 has been amended as follows:

When the sintered aluminum nitride is in the form of a sheet, the scrap zones 4 are generally provided as a sheet periphery and a partition zone between small chips cut out, each having a width of 0.3 to 2 mm.

Paragraph beginning at page 14, line 8 has been amended as follows:

The method of furnishing the aluminum nitride molding with through-holes for dummy via hole formation will now be described in detail with reference to Fig. 2 showing the aluminum nitride molding furnished with through-holes 2 for via hole formation according to the prior art and Fig. 1 showing the aluminum nitride molding of Fig. 2 further furnished with through-holes 3 for dummy via hole formation according to the present invention. Referring to Fig. 2, the aluminum nitride molding 1 is fired into the sintered aluminum nitride, from which a multiplicity of rectangular small chips are cut out as shown by partition lines. In the aluminum nitride molding 1, through-hole 2 for formation of a via hole used for electrical connection of both major surfaces of a substrate is disposed in the center of each small chip partitioned. Each through-hole 2 for via hole formation is in such a highly isolated state that, within a radius of 5.0 mm from the through-hole center (within dotted line circle), other through-holes for via hole formation are only present in the aforementioned amount. When ~~this~~ the conventional aluminum nitride molding 1 of Fig. 2 is fired ~~as it is~~, the ~~obtained~~ sintered aluminum nitride would be likely to suffer from, as aforementioned, poor densification of via holes and hence problems of cracking and a drop of the positional accuracy of via holes would result.

Partial paragraph beginning at page 15 line 21 has been amended as follows:

In the present invention, the aluminum nitride powder for constituting the aluminum nitride molding is not particularly limited, and a known ~~one~~ powder can be used. In particular, aluminum nitride powder of 5 μm or less average particle diameter is preferred, aluminum nitride powder of 0.3 μm or less average particle diameter is still more preferred, and aluminum nitride powder of 0.5 to 2 μm average particle diameter is especially preferred, the average particle diameter measured by the sedimentation method. Moreover, the aluminum nitride powder having an average particle diameter D1 as calculated from the specific surface area thereof and an average particle diameter D2 as measured by the sedimentation method which satisfy the following formulas,

Paragraph beginning at page 16, line 20 has been amended as follows:

In the aluminum nitride powder, the oxygen content is 3.0% by weight or less, and, when the aluminum nitride composition is AlN, the content of cationic impurities is 0.5% by weight or less. It is especially preferred to employ an aluminum nitride powder wherein the oxygen content is in the range of 0.4 to 1.0% by weight, the content of cationic impurities 0.2% by weight or less, and the total content of Fe, Ca, Si and C among cationic impurities 0.17% by weight or less. When this aluminum nitride powder is employed, the ~~obtained~~ resulting sintered aluminum nitride exhibits a ~~highly~~ greatly increased thermal conductivity.

Paragraph beginning at page 19, line 1 has been amended as follows:

~~As the conductive paste with which the~~ The thus formed through-holes for via hole formation and through-holes for dummy via hole formation are filled~~,~~ ~~there can be used one~~ with a conductive paste obtained by mixing ~~the~~ a refractory metal powder and an organic vehicle into a paste.

Paragraph beginning at page 20, line 11 has been amended as follows:

It is generally preferred that the organic vehicle component be added in an amount of 2 to 9 parts by weight per 100 parts by weight of the refractory metal powder. When the amount of organic vehicle is less than 2 parts by weight, the inorganic substance powder cannot be satisfactorily dispersed and forming the same into a paste is difficult, so that the filling property would be deteriorated. On the other hand, when the amount of organic vehicle is greater than 9 parts by weight, the inorganic substance concentration of the conductive paste becomes relatively low ~~with~~ causing the unfavorable ~~result that~~ occurrence of poor densification of the via holes ~~would tend to occur~~.

Paragraph beginning at page 20, line 23 has been amended as follows:

In the present invention, the conductive paste preferably contains ~~the powdery~~ an aluminum nitride powder. The aluminum nitride powder is effective in enhancing the sinterability of the refractory metal and enhancing the adherence thereof to the sintered aluminum nitride molding 1. Further, by virtue of the presence of the aluminum nitride powder in the conductive paste, the difference ~~of~~ in the shrinkage factor between the aluminum nitride portion and conductive portion is reduced to thereby enhance the dimensional stability of sintered product ~~with the result~~ in order that the object of the present invention can be more favorably ~~be~~ attained.

Paragraph beginning at page 21, line 9 has been amended as follows:

With respect to the aluminum nitride powder, a known ~~one~~ powder can be used without any particular limitation. In particular, the aforementioned aluminum nitride powder preferably used in the aluminum nitride molding is excellent in the sinterability with the refractory metal and is effective in enhancing the adherence of the conductive portion. The aluminum nitride powder is generally added in an

amount of 2 to 10 parts by weight, preferably 3 to 7 parts by weight, per 100 parts by weight of the refractory metal powder.

Paragraph beginning at page 21, line 18 has been amended as follows:

In the conductive paste composition, when the amount of aluminum nitride is less than 2 parts by weight, the adhesion strength between the conductive portion and the sintered aluminum nitride tends to decrease, or the shrinkage factor difference between the sintered aluminum nitride portion and the conductive portion tends to increase, so that the danger of void occurrence at a junction interface would be high. On the other hand, when the amount of aluminum nitride is greater than 10 parts by weight, the viscosity of the conductive paste tends to increase so as to suffer deterioration of the filling property. As a result, the adhesion strength between the conductive portion and the sintered aluminum nitride tends to be decreased by voids ~~having occurred~~ occurring in the conductive portion, or the surface of the conductive portion tends to be discolored by the aluminum nitride, to thereby invite the danger of an increase of electrical resistance of the via holes. Moreover, in the event that voids have occurred at the junction interface or in the conductive portion as mentioned above, a gas or liquid would be trapped in the voids in the process of thin film formation with the result that a film detachment by expansion of gas or liquid, or a drop of film adhesion strength by dirt sticking to the surface of sintered product would tend to occur.

Paragraph beginning at page 23, line 11 has been amended as follows:

With respect to the method of dewaxing, generally performed methods can be employed without limitation. The dewaxing atmosphere is not particularly limited as long as ~~except for~~ an oxidative atmosphere such as atmospheric air which might oxidize the refractory metal is avoided. For example, there can preferably be

employed an atmosphere of an inert gas such as nitrogen, argon or helium; an atmosphere of a reducing gas such as hydrogen; an atmosphere of a gas consisting of a mixture thereof; an atmosphere of a gas thereof which has been humidified; or a vacuum.

Paragraph beginning at page 25, line 20 has been amended as follows:

In order to obtain ~~the~~ sintered aluminum nitride of high thermal conductivity, it is desirable to fire the aluminum nitride molding ~~having~~ after it has been dewaxed so that the residual carbon ratio of the aluminum nitride molding falls within the range of 800 to 3000 ppm (hereinafter referred to simply as "dewaxed material") at 1200 to 1700°C, preferably 1500 to 1650°C, and thereafter 1800 to 1950°C, preferably 1820 to 1900°C. When dewaxing is performed so as to ensure a high residual carbon ratio, the resultant sintered aluminum nitride is generally likely to suffer from the problems of poor densification of via holes and poor appearance such as cracking, while the above high thermal conductivity can be ensured. These problems can be resolved by the above two step firing.

Paragraph beginning at page 26, line 23 has been amended as follows:

It is preferred that the first-step firing temperature range from 1500 to 1650°C from the viewpoint that the oxygen removing reaction by reduction can be promoted with especially high efficiency so as to increase the thermal conductivity of the sintered aluminum nitride. When the second-step firing temperature is lower than 1800°C, it would not be ~~infeasible~~ feasible to satisfactorily sinter the aluminum nitride. As the result, it would not be ~~infeasible~~ feasible to satisfactorily increase the thermal conductivity of the sintered aluminum nitride.

Partial paragraph beginning at page 32, line 11 has been amended as follows:

On a sintered aluminum nitride after ~~polish~~ being polished like a mirror surface, five via holes were randomly selected, and the diameters thereof were measured and averaged to thereby obtain an average diameter Ra. The firing shrinkage factor was calculated by the formula:

Partial paragraph beginning at page 32, line 17 has been amended as follows:

wherein Ra represents an average of the diameters of five via holes measured on a sintered aluminum nitride after ~~polish like~~ being polished to a mirror-like surface, and Rb represents the diameter of a punching metal mold employed for forming the through-holes for via hole formation.

Paragraph beginning at page 32, line 24 has been amended as follows:

With respect to each of the through-holes of aluminum nitride molding for formation of five via holes selected in the above measurement of firing shrinkage factor (Xv), the center distance of two via holes of remotest positional relationship opposite to each other, with at least part of the above through-hole for via hole formation interposed therebetween was measured by the use of a measure scope. The two via holes are selected from the other through-holes via hole formation and through-holes for dummy via hole formation which were present within a radius of 5.0 mm from the center of the through hole for via hole formation used for measurement of (Xv). The measured center distances were averaged, and designated Lb. Moreover, with respect to the sintered product from the aluminum nitride molding, after ~~polish~~ being polished like a mirror surface, the center distances between two via holes derived from the other through-holes for via hole formation and through-holes for dummy via hole formation used for measuring the above

average Lb were measured. The measured center distances were averaged, and designated La.

Partial paragraph beginning at page 34, line 5 has been amended as follows:

Sintered aluminum nitride was subjected to ~~polish like~~ polishing to produce a mirror-like surface. In a high vacuum of 10^{-3} torr, 0.06 μm thick Ti, 0.2 μm thick Pt and 0.6 μm thick Au metallic thin films were sequentially formed on the surface by sputtering. The resultant sintered aluminum nitride was allowed to stand still in the atmospheric air at 450°C for 5 min, and the appearance thereof was observed by visual inspection and through a stereomicroscope (μ40). The appearance was evaluated on the following criteria:

Paragraph beginning at page 35, line 10 has been amended as follows:

Sintered aluminum nitride, after ~~polish like a~~ polishing to mirror-like surface, was cut and divided into small chips. Thereafter, the electrical resistance of via holes was measured.

In the claims:

Claim 5 has been amended as follows:

5. The process as claimed in ~~any of claims 1 to 4~~ claim 1, wherein through-holes for dummy via hole formation are formed in a scrap zone within the sintered aluminum nitride.

Claim 7 has been amended as follows:

7. The process as claimed in ~~any of claims 1 to 6~~ claim 1, wherein a composition comprising 100 parts by weight of a refractory metal, 2 to 10 parts by weight of powdery aluminum nitride and 2 to 9 parts by weight of an organic vehicle is used as the conductive paste.

In the abstract:

The section heading beginning at page 51 line 1 has been amended as follows:

ABSTRACT OF THE DISCLOSURE